EXTENSION NOTE

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# Tree Growth on Rehabilitated Skid Roads in Southeastern British Columbia

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■ **This study examined tree growth on rehabilitated skid roads that had undergone incomplete rehabilitation (recontouring alone) and that were characterized by extreme growing conditions, including unfavourable substrates, short growing season, and excessive moisture.**

■ **Overall, the favourable growth of trees on the berm treatments indicates the potential of skid-road rehabilitation for restoring site productivity.**

## INTRODUCTION

In the Nelson Forest Region in southeastern British Columbia, ground skidding is the dominant method of harvesting, accounting for approximately two thirds of the volume logged.[1] Historically, soil disturbance on ground-skidded sites has been relatively high because skid roads (excavated and bladed trails) usually occupy a significant portion of the harvesting site. For example, older studies showed that in clearcuts on steep slopes, skid roads often accounted for over 20% of the harvest area (Smith and Wass 1980; Krag et al 1986). While disturbance levels were substantially reduced as a result of various soil disturbance guidelines developed in the 1980s (such as the *Interim Soil Conservation Guidelines for Timber Harvesting* [British Columbia Ministry of Forests 1989]), un-rehabilitated skid roads still represented potential threats to on-site hydrology and productivity, and off-site resource values (Thompson and Osberg 1992). Loss of site productivity may occur either due to the effects of compaction, including decreased soil penetrability, altered site hydrology, and/or decreased soil aeration; or through nutrient loss caused by disturbance/removal of surface soil horizons or by mixing of surface soil horizons with unfavourable substrates (Smith 1988).

Several studies have documented reduced tree growth on skid roads, varying from 15 to 59%, averaged over the skid-road area, relative to tree growth on undisturbed soil (Smith and Wass 1979, 1980; Thompson et al 1990; Thompson 1991). Even a conservative estimate of tree-growth reductions, when prorated over the area covered by skid roads in a cutblock, has significant implications for reducing a site's future volume yield. For example, if skid roads cover 13% of the cutblock, and loss of site productivity averages 30% on the skid roads, then the total volume yield for the site is reduced by 3.9%. This loss of site productivity has corresponding implications for reducing the allowable annual cut.

Implementation of the *Forest Practices Code of British Columbia Act* (FPC) in 1995 made skid-road rehabilitation immediately mandatory on many harvesting sites, and it will be required on all sites by December 1999. Productivity and slope hydrology are to be restored to the satisfaction of the Forest District Manager. It is implied in the FPC that full productivity and slope hydrology will be restored by the rehabilitation of skid roads. However, at the time of FPC implementation, it was not proven that operational rehabilitation projects would achieve this goal, and optimum rehabilitation techniques had not yet been demonstrated.

Forest managers must consider environmental risk and legal requirements, and balance these with sensible economic solutions. Skid-road rehabilitation has an estimated cost of $1.50/m³, utilizes equipment available during the harvesting operation, and provides employment. This compares favourably to cable harvesting, which generally costs $10.00/m³ more than ground-based skidding; most of which is equipment cost, resulting in a corresponding loss of employment and government revenue. However, in order to apply skid-road rehabilitation practices appropriately, site-specific knowledge regarding the acceptability of ground-based skidding and the viability of skid-road rehabilitation is needed by District Managers and operational staff.

In 1995 a study was initiated in the Nelson For-

[1] Harvest Database System, Revenue Branch, BCMOF, 1996.

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est Region of the British Columbia Ministry of Forests (BCMOF) to quantify tree growth on existing rehabilitated skid roads in order to make recommendations about improving the rehabilitation techniques that were in use at the time. This Extension Note explains the methodology of this study, presents tree-growth results as of 1996, and provides management and operational recommendations for implementing skid-road rehabilitation.

## STUDY AREAS

Ten study sites were selected to provide a range of extreme growing conditions (Table 1). Climatic variation was incorporated by selecting sites in several biogeoclimatic subzones/variants. The study included "retrospective" sites (sites that had been operationally planted or naturally regenerated after rehabilitation), as well as experimental installations where trees had been systematically planted on the various parts of the skid road (undisturbed, inner track, midroad, and berm; Figure 1). Five sites are in the western ranges of the Rocky Mountains: Lussier River, East Lussier River, Dry Creek, East Grave Creek, and North Grave Creek. Three sites are in the Purcell Mountains: Bloomridge, Caven Creek, and McMurdo Creek. Because rehabilitated skid roads were unavailable in the West Kootenays, two rehabilitated haul road locations were selected in the Selkirk Mountains (Bell Creek and Hudu Creek).

At most sites, the rehabilitated area was originally a skid road that closely followed the contour. Rehabilitation treatment at all sites consisted of recontouring (replacing) the sidecast material. All sites had planted or naturally regenerated stock that was three years old or older. The species studied were lodgepole pine (*Pinus contorta*), Engelmann spruce (*Picea engelmannii*), and Douglas-fir (*Pseudotsuga menziesii*).

## STUDY METHODS

Two representative sections of rehabilitated skid road within each retrospective cutblock were selected from a reconnaissance walk throughout the block. Sample sections of skid road were required to be continuous, and the top of the cutbank and original cross section were usually clearly discernible. All trees in the skid-road section were measured in four disturbance categories: undisturbed, inner track, midroad, and berm (including sidecast; Figure 1). In general, fifteen trees per disturbance type were measured within each of the two skid-road sections. In the planted cutblocks, basal diameter, total height, and annual height increment were measured from the ground level. In the naturally regenerated block, it was necessary to fell the trees at a point 20 cm above the root collar and count the annual rings to determine their age; height and basal diameter were measured as described above.

### Analysis

Analysis of variance (ANOVA) and disturbance type contrasts (comparisons of growth between treatment types) were the primary analyses used. The data were analyzed in two groupings: regionally, across all blocks and all species to determine region-wide trends; and within a biogeoclimatic zone (ESSF) to ascertain sub-regional trends. Within the biogeoclimatic analysis a by-species analysis was conducted to examine species-specific responses to skid-road treatments. Analysis was done at the cur-

*Table 1. Descriptions of study sites.*

| Site | Type of trial | Tree species | Tree age [a] (y) | Biogeoclimatic subzone [b] | Elevation (m) | Aspect |
|---|---|---|---|---|---|---|
| Bell Creek [c] | Retrospective | Fd | 7 | ICHdw | 960 | W |
| Bloomridge | Established | Pl | 4 | MSdk | 1440 | W |
| Caven Creek | Retrospective | Pl | 5-9 [d] | MSdk | 1110 | N |
| Dry Creek | Established | Pl | 4 | ESSFdk | 1720 | S |
| Grave Creek | Established | Pl & Se | 5 | ESSFdk | 1760 | E & N [e] |
| Hudu Creek | Retrospective | Pl | 6 | ICHmw2 | 1170 | S |
| East Lussier River | Established | Pl | 3 | ESSFdk | 1760 | N |
| Lussier River | Retrospective | Pl | 7 | ESSFdk | 1530 | SW |
| McMurdo Creek | Retrospective | Se | 6 | ESSFwm | 1700 | N |

[a] Fd = Douglas-fir. Pl = lodgepole pine. Se = Engelmann spruce. [b] Braumandl and Curran 1992. [c] Bell Creek and Hudu Creek are haul road sites. For preliminary work, only five trees per disturbance type, per road, were measured. [d] Caven Creek is a naturally regenerated site, recontoured in 1984. [e] The different aspects at Grave Creek are treated as separate sites, i.e. East Grave Creek and North Grave Creek.

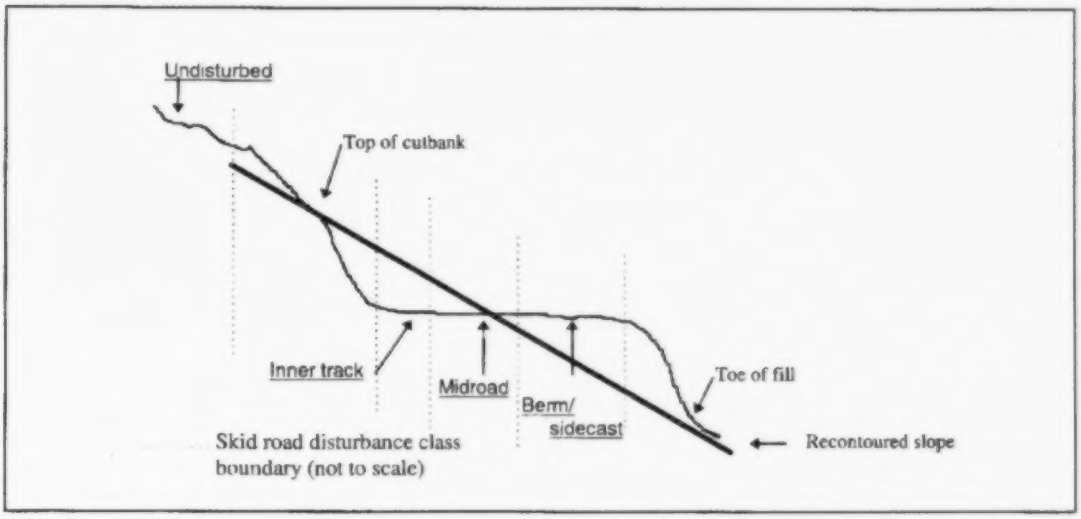


*Figure 1. Cross section of skid-road treatments. Undisturbed trees were those located a minimum of 2 m from, and preferably above, the skid road. Due to the low stocking in the undisturbed areas, trees were sometimes located 5-10 m from the skid road. Inner track trees were located within 1.8 horizontal metres of the top of the cutbank. Midroad trees were located 1.8-3.0 m from the top of the cutbank. Berm trees were located on intact deposits that were still continuous with the cutbank, and 3.0-4.5 m from the top of the cutbank.*

rent age (the age at the time of measurement in 1996) of each block, as well as at five-year height (five years after outplanting) for some analyses; the latter was done to establish a relative age for growth result comparisons. Total height and three-year height increment were the variables considered at five-year height. At the current age for the blocks, three-year height increment, total height, volume, and diameter were analyzed. Volume was calculated as 1/3 (base x height).

## RESULTS

Trees growing on the berm/sidecast and undisturbed treatments commonly displayed better growth than trees growing on the inner track and midroad. For example, in the analysis of all ten blocks for three-year increment, berm trees were either the leading or second-ranked treatment in seven of ten blocks, with differences in growth from the undisturbed (100%) ranging up to 161% (Figure 2). Total and three-year height growth of the trees growing on the berm and undisturbed were also significantly better in the ESSF analysis. Diameter growth and volume (Figure 3) followed the same trend as height for all analyses.

Previous studies of tree growth on un-rehabilitated skid roads have shown that trees growing on the undisturbed or sidecast (berm) demonstrate the best growth, with trees growing on the berm often showing better growth than the trees growing on the undisturbed (Thompson 1991; Thompson et al 1990; Smith and Wass 1979, 1994b). In this study the growth of all trees growing on rehabilitated skid roads was expected to be similar to that of trees growing on the berm in previous studies. Surprisingly, this was rarely the case, and trees growing on the midroad and inner track typically grew worse than trees growing on the berm and undisturbed. The results are presumably due to growth limitations characteristic of skid roads, such as subsurface compaction from these old trails not being decompacted, or site-specific growth-limiting factors such as competing vegetation (seeded grass) or unfavourable substrates.

The better growth of the trees on the berm may be attributed to the fact that the roots of these trees have access to intact, buried forest floor and surface soil which were not part of the bladed structure. The compacted running surface of the original skid road is still intact under the recontoured slope, and may be affecting the growth of trees on the inner track and midroad. Compaction effects are more pronounced in clayier soils, where a virtually impenetrable hardpan layer develops, resulting in inferior root formation and reduced tree growth. The trees growing on the berm may also benefit from the downslope export of water off of the subsurface compaction.

Smith and Wass (1994a) demonstrated that soil disturbance associated with the construction of excavated skid roads in a calcareous (high pH) soil has a negative correlation to tree growth. Calcareous soil can have a negative impact on tree growth because it has poor physical properties, an alkaline pH, and is low in nutrients such as iron and phosphorus. This unfavourable substrate will be present in the growing medium of a rehabilitated skid road that is recontoured with the excavated material. Trees growing on the berm may not suffer as much from high pH in the growing medium because their root systems have better access to more acidic, undisturbed forest floor and intact topsoil.

Spruce generally had a greater range of responses to the different treatments than did pine. In addition to significantly better growth on the berm and undisturbed treatments, only in the spruce blocks were trees on the midroad growing significantly less than all other treatments, both

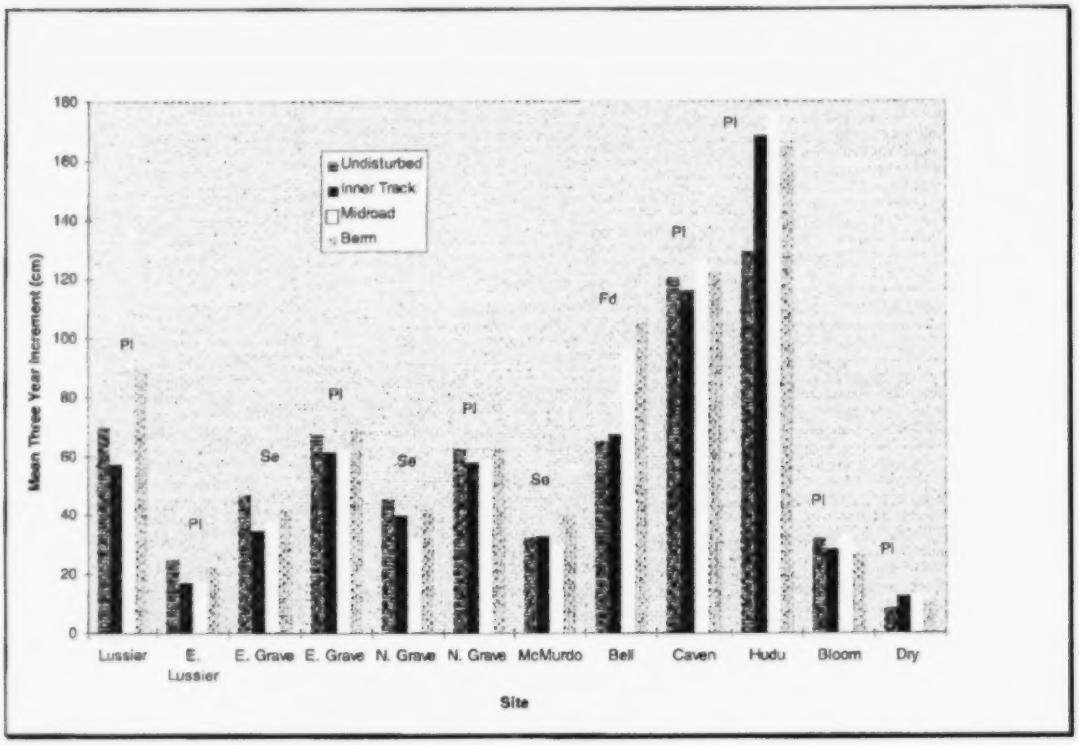


*Figure 2. Three-year increment at 1996 block height, all blocks and species. Pine and spruce are shown separately at East Grave Creek and North Grave Creek.*

at five-year height and at the time of measurement in 1996. In addition, only in the spruce blocks were the undisturbed trees growing significantly better than all other treatments at five-year height. The different growth responses may be attributed to the inherent growth characteristics of the two species.

Lodgepole pine is a colonizing species, and tends to grow well on disturbed soils and on soils with underlying hardpan where other species would suffer (Lotan and Critchfield 1990; Alexander and Shepperd 1990). The early growth trajectory of pine seedlings is also steeper than that of spruce; pine reaches breast height in half the time of spruce (Thompson 1995, 1996). These characteristics make pine generally better adapted to growth on skid roads than spruce. In contrast, spruce is more tolerant of vegetative competition and shade, which may explain why the trees on the undisturbed grew significantly better in the spruce blocks; whereas pine growth on the undisturbed areas may have been compromised due to vegetation competition. Pine does especially poorly in competition with grass, which may be affecting the growth of skid-road trees at those sites with grass competition, namely Bloomridge.

Wildlife browse occurred to some extent at most sites, and to a great extent at some sites. Although this study primarily examined growth of healthy trees, other factors that inhibit or advance tree growth are of interest. Browsing may be worse on some treatments, and will be examined at the next measurement in 1999.

The ICHdw, MSdk, and ESSFdk biogeoclimatic subzones have many examples of successful skid-road rehabilitation, while the ICHmw2 (Hudu Creek) and ESSFwm (McMurdo Creek) biogeoclimatic subzones have only limited examples of successful skid-road rehabilitation (Nelson Forest Region 1995). The consistently better growth on the berm treatment at wetter and colder McMurdo Creek, and on all skid-road treatments at wetter and warmer Hudu Creek, demonstrate the effectiveness of skid-road rehabilitation in biogeoclimatic zones which previously had limited examples of the practice.

## CONCLUSIONS

This study examined tree growth on rehabilitated skid roads that had undergone incomplete rehabilitation (recontouring alone) and that were characterized by extreme growing conditions, including unfavourable substrates, short growing season, and excessive moisture. Overall, the favourable growth of trees on the berm treatments indicates the potential of skid-road rehabilitation for restoring site productivity.

On appropriate sites, ground-based skidding with full rehabilitation is more economically desirable than cable harvesting; however, cable harvesting is still preferable on steeper slopes and sensitive soils. There is a clear

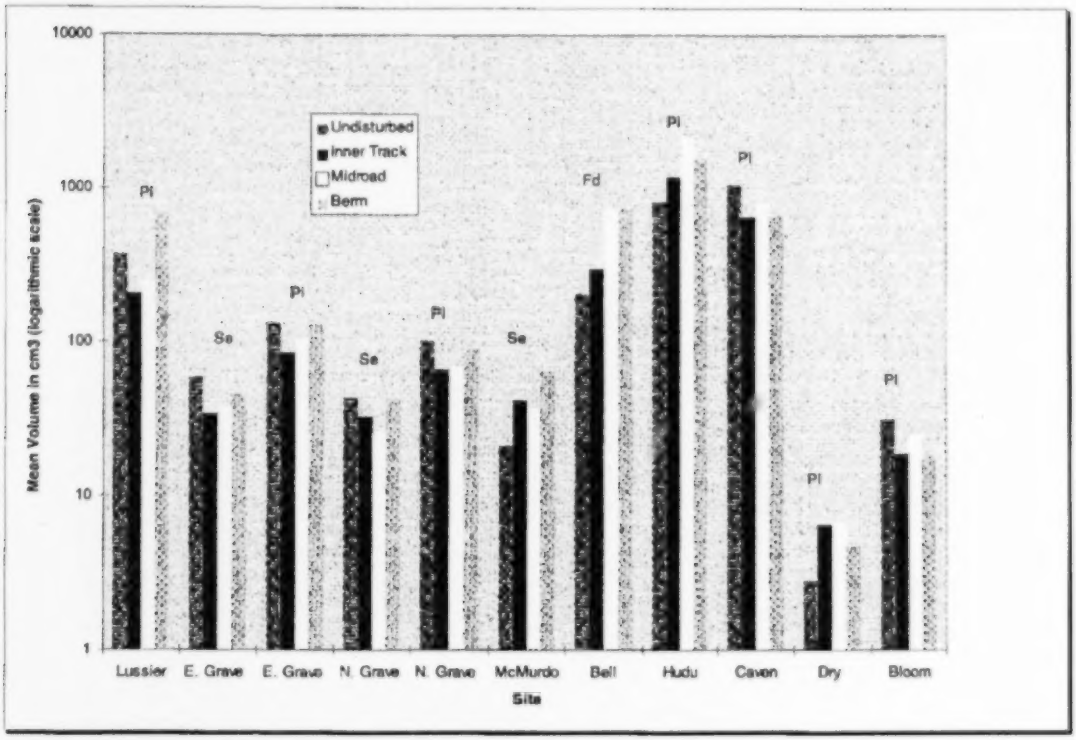


*Figure 3. Tree volume at 1996 block height, for all species. Pine and spruce are shown separately at East Grave Creek and North Grave Creek. (Volume not available for East Lussier River because diameter measurements were not taken.)*

need to balance the practice of skid-road rehabilitation as defined by restored site productivity, with economics, employment, and environmental risk.

## RECOMMENDATIONS

Tree growth on skid roads may be improved through the use of techniques that attempt to restore the soil to its original (pre-harvest) state. The following practices should guide forest managers and machine operators in the construction and rehabilitation of skid roads.

- To eliminate subsurface compaction, the running surface of the skid road should be decompacted (fluffed) in an outsloping manner prior to recontouring the slope.
- Drainage control is a priority when constructing and rehabilitating skid roads. Seepage areas should be avoided during skid-road construction, and water bars or other methods should be employed to restore drainage patterns during construction and rehabilitation.
- Topsoil should be kept separate during skid-road construction, in order to reassemble the soil to its original state upon rehabilitation. In practice, two lifts should be employed: store the topsoil in the sidecast area, and construct the running surface from the subsoil. This is particularly important when constructing a skid road in a soil with unfavourable substrates.
- Site-specific growth-limiting factors should be considered and addressed by using rehabilitation techniques and species selection. Skid-road rehabilitation may provide an opportunity to perform site preparation on the undisturbed area adjacent to the skid roads on heavily vegetated or cold soil sites.
- Machine operator training is critical to successful skid-road rehabilitation. Field cards and a video that demonstrate tested rehabilitation techniques are available (Curran 1997 [2]). Machine operators should also be trained to recognize soil layers.

In addition, ongoing cooperative research is continuing, and includes different biogeoclimatic zones and rehabilitation techniques.

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[2] The field cards and video are available directly from Mike Curran at the Nelson Forest Region. See "For Further Information".

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